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FAILURE MECHANISMS IN AIRCREW HELMET VISORS

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The causes for removing aircrew helmet visors from service were investigated as part of the Armstrong Laboratory's Advanced Aircrew Vision Protection (AAVP) program. The reason for the investigation was to identify better technologies, specifications, or procedures that could be applied to the aircrew laser eye protection (ALEP) visors being transitioned under the AAVP program. Clear and neutral gray (sun) visors that were identified to be discarded were requested and received from four Air Force life support units. Fifty-three (53) visors, 44 sun and 9 clear, were received and examined. The procedures used and the results of this study are presented here. The single cause of visor degradation that resulted in removing it from service was found to be damage to the surface hard coating, primarily scratches.

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INTRODUCTION

The causes for removing aircrew helmet visors from service were investigated as part of the Armstrong Laboratory's Advanced Aircrew Vision Protection (AAVP) program. The reason for the investigation was to identify better technologies, specifications, or procedures that could be applied to the aircrew laser eye protection (ALEP) visors being transitioned under the AAVP program. Clear and neutral gray (sun) visors that were identified to be discarded were requested and received from four Air Force life support units. Fifty-three (53) visors, 44 sun and 9 clear, were received and examined. The procedures used and the results of this study are presented here. The single cause of visor degradation that resulted in removing it from service was found to be damage to the surface hard coating, primarily scratches.

STUDY DESCRIPTION

A study of 53 Air Force pilot helmet visors that had been removed from service was conducted to determine the nature and characteristics of defects that caused their loss of serviceability. The visors were obtained from four different operational units. The units that provided visors included the 555th Fighter Squadron, 461st Fighter Squadron, 12th Training Wing, and 149th ANG. Nine clear visors and 44 sun visors were received and evaluated. The visors were systematically examined to determine the location and types of defects that were evident. Both the front and back surfaces of each visor were examined. Nine different positions on the visors were designated for inspection purposes. These nine positions are shown in Figure 1 and correspond to the nine positions designated in MIL-V-43511C[1] (Figure 4) for visor inspection. Although the nine positions were designated for reference, the whole visor was inspected. The three areas designated 3, 1R, and 1L, which are directly in front of the pilot's eyes, are referred to as critical areas for the purpose of this study, and all other positions are designated as non-critical areas. MIL-V-43511C[1] designates all of the nine locations as being within the critical area of vision, but for the purpose of this study only the three central areas were designated as critical since a defect in these central areas would be most likely to cause removal of the visor from service. In addition to the examination and recording of existing defects, an adhesion test was performed on the visor coating. The adhesion test used was the scotch tape test described in paragraph 4.2.3.1 of MIL-C-83409.[2]

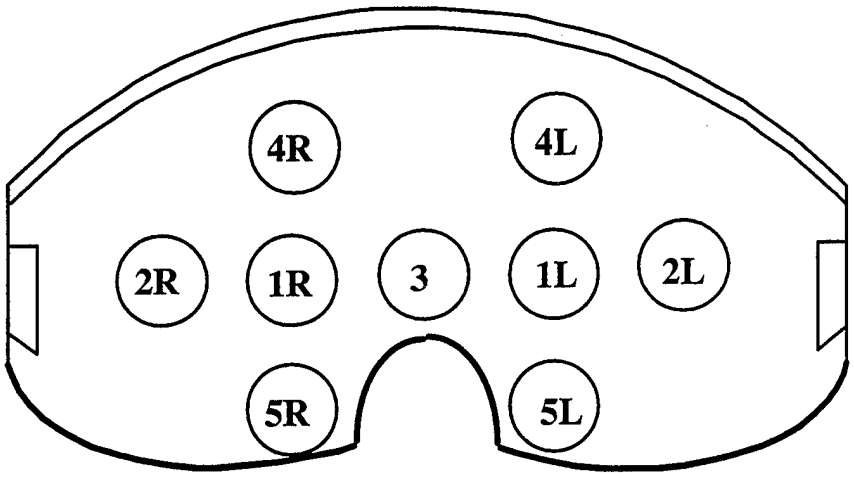


Figure 1: Designated Areas of Visor (Front View)

CLASSIFICATION AND TYPES OF DEFECTS

Defects on the visors were categorized by classification and type. A defect on a visor was classified as a scratch, a dig, a delamination, or a scuff. The scratches were further categorized as Type 1, Type 2, or Type 3. These classifications and types as well as the methods of examination were patterned after those used by Scott Aviation and described in their Technical Report No. 561-954,[3] Evaluation Requirements for Commercial and Military Visor Lenses, June 27, 1986, and are based on a shadowgraph inspection. The definitions of the classifications and types of defects are as follows:

Scratches

Scratches are long narrow areas of damage to the coating and/or the surface of the lens.

- Type 1 scratches are visible to the unaided eye and appear on the shadowgraph screen as a dark line.
- Type 2 scratches are visible to the unaided eye and appear on the shadowgraph screen as a faint line.
- Type 3 scratches are visible to the unaided eye and are not visible on the shadowgraph screen.

Digs

Digs are gouges or pits in the surface of the lens.

Delamination

Delamination is caused by a loss of adhesion of the coating to the part, which may be evidenced by peeling away of the coating.

Scuff Marks

Scuff marks are surface abrasions.

INSPECTION AND TEST PROCEDURES

Visor Inspection

Prior to inspection, all visors were thoroughly cleaned to remove dirt, oil, and fingerprints. A visual examination of the visor was performed by looking through the visor at a lighted white background with the visor approximately 12 inches from the examiner. The entire visor was examined, front and back, and the findings were documented. After the visual inspection, the visors were put on a shadowgraph (Vu-Graph projector) for further evaluation. The projector used was a Bell and Howell 360G, 650-watt projector, and the surface of the visor was imaged on a screen 72 inches from the projector. The visors were centered on the projector convex side (outside) up with the nose cut facing the screen. The visors were rotated clockwise and counterclockwise to examine the entire area. Critical and non-critical areas were inspected for defects. The classification, type, location, and number of defects were noted and recorded. The same procedures were then used for the concave side (inside) of the visor.

Scotch Tape Test

This procedure tests the adhesion of the visor hard coating to the polycarbonate material of the visor. Scotch tape with an adhesion rating of 40 ounces per inch is firmly applied to the area of the lens to be tested. The tape is then removed, using a snap motion applied at 90 degrees to the lens surface, and the lens is examined for loss of coating in the area tested.

SUMMARY OF FINDINGS

The findings of the study of visor failure mechanisms and coating adhesion testing are given below. The failure mechanism data are presented in tabular and graphical formats. The average number of scratches per visor, the number of visors evidencing

different type of scratches, and the number of visors evidencing different type of defects are presented.

Scotch Tape Test Results

Nine of the 53 visors (17%) failed the scotch tape test (i.e., the coating was removed when the scotch tape was pulled from the visor). Ten of the visors (19%) evidenced delamination of the coating when they were removed from service. There was not a one-to-one correspondence between the visors that had delamination of the coating when removed from service and those that failed the scotch tape test.

Visor Damage Found

Table 1: Average Number of Scratches per Visor per Type of Scratch by Location

Type 1 scratch	11.57 total	7.72 front	3.85 back
Type 2 scratch	5.63 total	4.09 front	1.46 back
Type 3 scratch	13.13 total	5.04 front	8.09 back

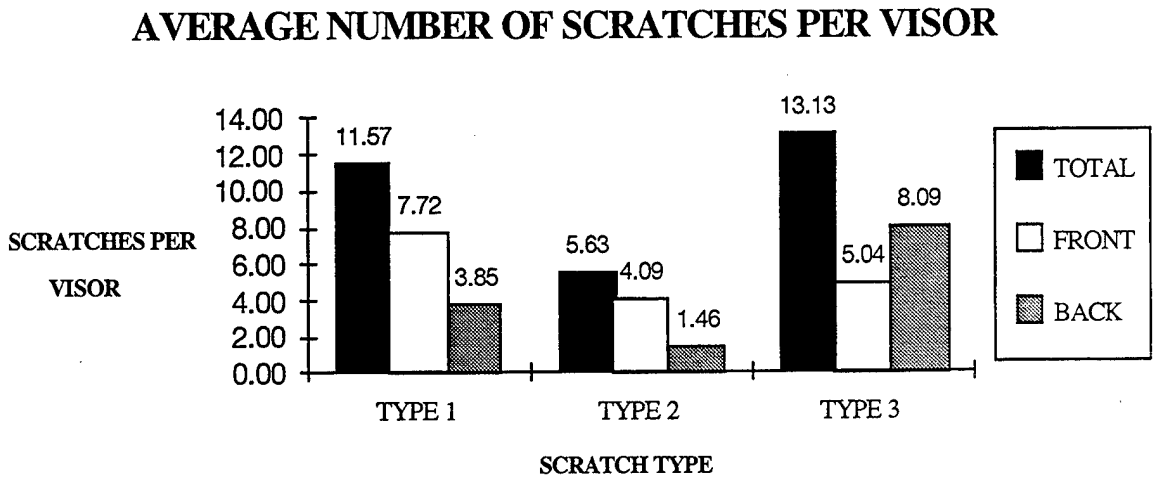


Table 2: Number of Visors Evidencing Each Type of Scratch by Location

Type 1 scratch	48 total	42 front	22 back	19 critical area
Type 2 scratch	37 total	33 front	10 back	9 critical area
Type 3 scratch	53 total	42 front	41 back	39 critical area

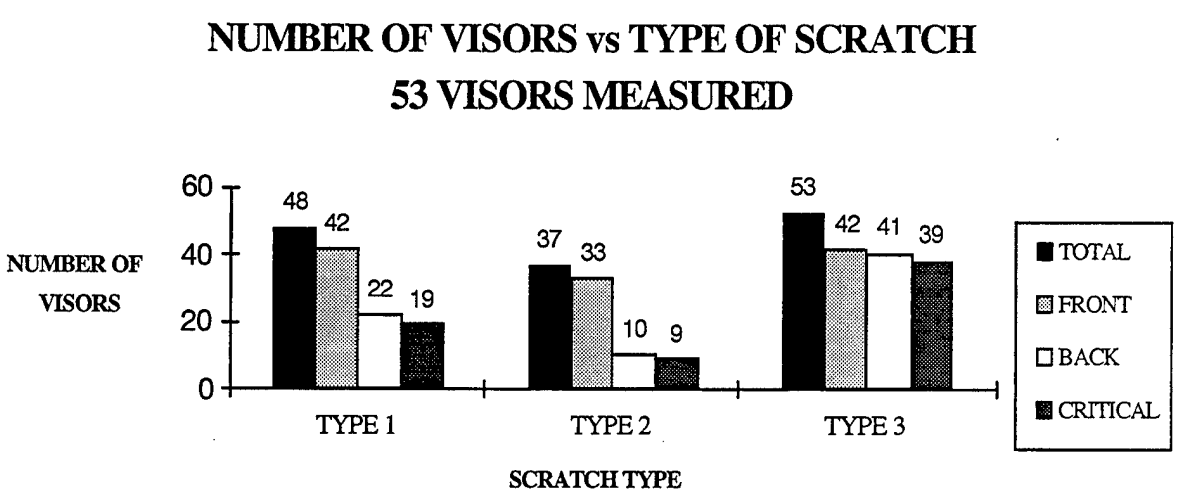
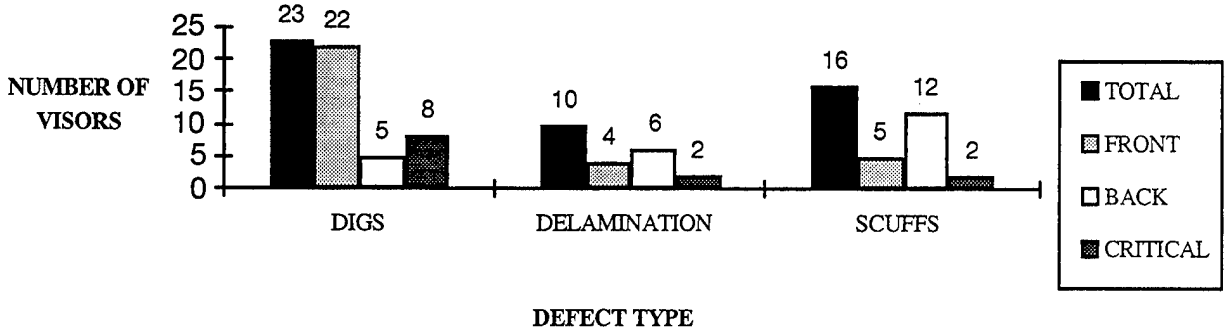


Table 3: Number of Visors Evidencing Each Type of Defect by Location

Digs	23 total	22 front	5 back	8 in critical area
Delamination	10 total	4 front	6 back	2 in critical area
Scuffs	16 total	5 front	12 back	2 in critical area



CONCLUSIONS

From the systematic examination and analysis of the defects on 53 discarded pilot helmet visors it is concluded that damage to the visor hard coating, probably in the form of scratches, is the prevalent reason for removing a visor from service. It was found that 91% of the visors examined had Type 1 (heavy) scratches somewhere on the visor. All visors that were examined had Type 3 scratches, and 74% had Type 3 scratches in the critical area of vision. Type 1 and Type 2 (medium) scratches were found more often on the front (outer) surface. Type 3 (light) scratches were, however, found on the back (inner) surface on as many visors as had Type 3 scratches on the front surface. The average number of Type 3 scratches on the back surface was greater than on the front surface. Neither the classification (scratch, dig, delamination, or scuff) of the defect nor the type of scratch that had caused the visor to be removed from service could be conclusively determined from this study. The prevalence of scratches on all of the discarded visors would, however, suggest that scratches were the more probable cause. Delamination of the coating and/or poorly adhered coatings were evident in a significant number of the visors. Nineteen percent of the 53 visors examined evidenced existing delamination of the coating, and 17% of the visors tested failed the scotch tape adhesion test. Both of these defects would indicate a poor quality coating. These percentages, however, may be disproportionately high in terms of the visors in the USAF inventory because only visors that had been removed from service were examined.

REFERENCES

1. MIL-V-43511C, Visors, Flyer's Helmet, Polycarbonate. (Jul 90)

2. MIL-C-83409, Coatings, Visor, Polycarbonate, Flying Helmet. (Mar 86)

3. Evaluation Requirements for Commercial and Military Visor Lenses, Scott Aviation TR 561-954. (Jun 86)